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UNPUBLISHED PRELIMINARY DATA

10p.

NOISE INVESTIGATIONS WITH IMPINGING JET FLOWS *

by

Darshan S. Dosanjh Dec. 1963 0 refs

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SYRACUSE UNIVERSITY RESEARCH INSTITUTE, N.Y.

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General Remarks

The biannual status report No. 1 briefly covers the progress made during June 1, 1963 to November 30, 1963 on Noise Investigations with Impinging Jet Flows being conducted at Syracuse University under NASA Grant No. NsG-431. Also the difficulties encountered in obtaining a suitable space for housing the experimental noise facility on Syracuse University campus, the circumstances which led to such difficulties and the resulting delay in the actual start of the experimental work are stated in the report. To solve these and related problems, the construction of an anechoic chamber, with Syracuse University funds, was proposed by the project director. This proposal was much discussed and explored by Syracuse University authorities. The proposed construction of an anechoic chamber has been accepted now by Syracuse University Administration. The pertinent details are discussed in the report.

During the summer months (June to August, 1963) attention was directed to survey of existing literature, the needed experimental set up and its instrumentation and suitable housing of the jet noise experimental system. Brief comments on each of these tasks are presented below.

Literature Survey

Extensive survey of existing experimental and analytical literature on or related to jet noise (especially from high pressure ratio jet flows) was undertaken and pertinent literature was accumulated and studied. This also proved helpful, as an additional guide in planning the experimental facility and its instrumentation.

Instrumentation Requirements

The preliminary experimental observations (chiefly miscellaneous optical data) made earlier by us at Syracuse University on noise from highly underexpanded two dimensional impinging jet flows suggested that at the proposed maximum operating pressures of about 200 psig, the near field noise level of the discrete frequencies may be as high as 180 db. In these observations the two dimensional jet exit was only 1/32' wide. The near-field discrete frequency was deduced from optical observations to be about 125 KC. Using these as upper limits of the expected intensity level and frequency, the instrumentation and its availability was assessed. Considerable amount of correspondence was undertaken with various manufacturers of the electronic noise measuring equipment as well as the air flow equipment etc. It was apparent that the lower the cutoff frequency and higher the upper frequency limit, the costlier the equipment will be. The available and reliable off the shelf commerical narrow-band spectrum analysis equipment manufactured by Bruel and Kjaer as an operational unit has the upper frequency limit of about 40 KC. However if a tape recorder is used at a suitable speed for recording the jet noise and if a slower speed for the tape playback is properly selected, the expected high frequency content (125 KC or so) of the noise spectrum can be analysed within the range (40 KC or lower) of the commercially available equipment. However cost is a serious factor. Alternately, Bruel and Kjaer could custom manufacture 1/3 octave filters extending the upper limit of the frequency range of the noise measuring equipment to 100 KC. However this scheme does not permit narrow band noise spectrum analysis that the tape recorder scheme offers.

The alternative course is to use jets of relatively bigger diameters or exits so that the screech wavelength will be larger and is such that the frequency range in which the maximum energy content and/or screech occurs, lies within the useful range of the more easily available commercial equipment. The use of the bigger jets will mean the exclusion of the investigations of rather interesting high frequency noise characteristics. Furthermore the use of the bigger jets will restrict the available run time from the existing compressed air supply (storage capacity 450 ft^3 and maximum storage pressure 350 psia). For example with a one-inch diameter power jet operated at reservoir pressure of 200 psig interacting with another one inch diameter jet or jets of an equivalent exit area but operated at lower reservoir pressure (20 psig), the available maximum run time will be about 5 minutes. So the actual free time for experimental observations (after the control system is steady) will be about 3 minutes. This limitation on available run time will necessitate the use of some mechanized and automatic recording devices.

Therefore relative merits of the desired upper frequency limit, operational run time and cost considerations were carefully weighed. It was decided that the tape-recorder recording and playback technique in conjunction with the commercially available noise analyzing equipment shown in block diagram (Fig. 1) will provide the needed flexibility to cover experimentally an extended frequency range of noise intensity distribution over wide operating conditions such as operating reservoir pressures, jet exit diameters and flow times.

The original proposal indicated that Syracuse University will contribute [redacted] towards the purchase of some of the noise measuring equipment.

This sum was promptly appropriated by Syracuse University and currently the purchase orders are being prepared. The equipment items to be purchased from NASA grant funds are also being selected.

Space Allocation for Noise Facility

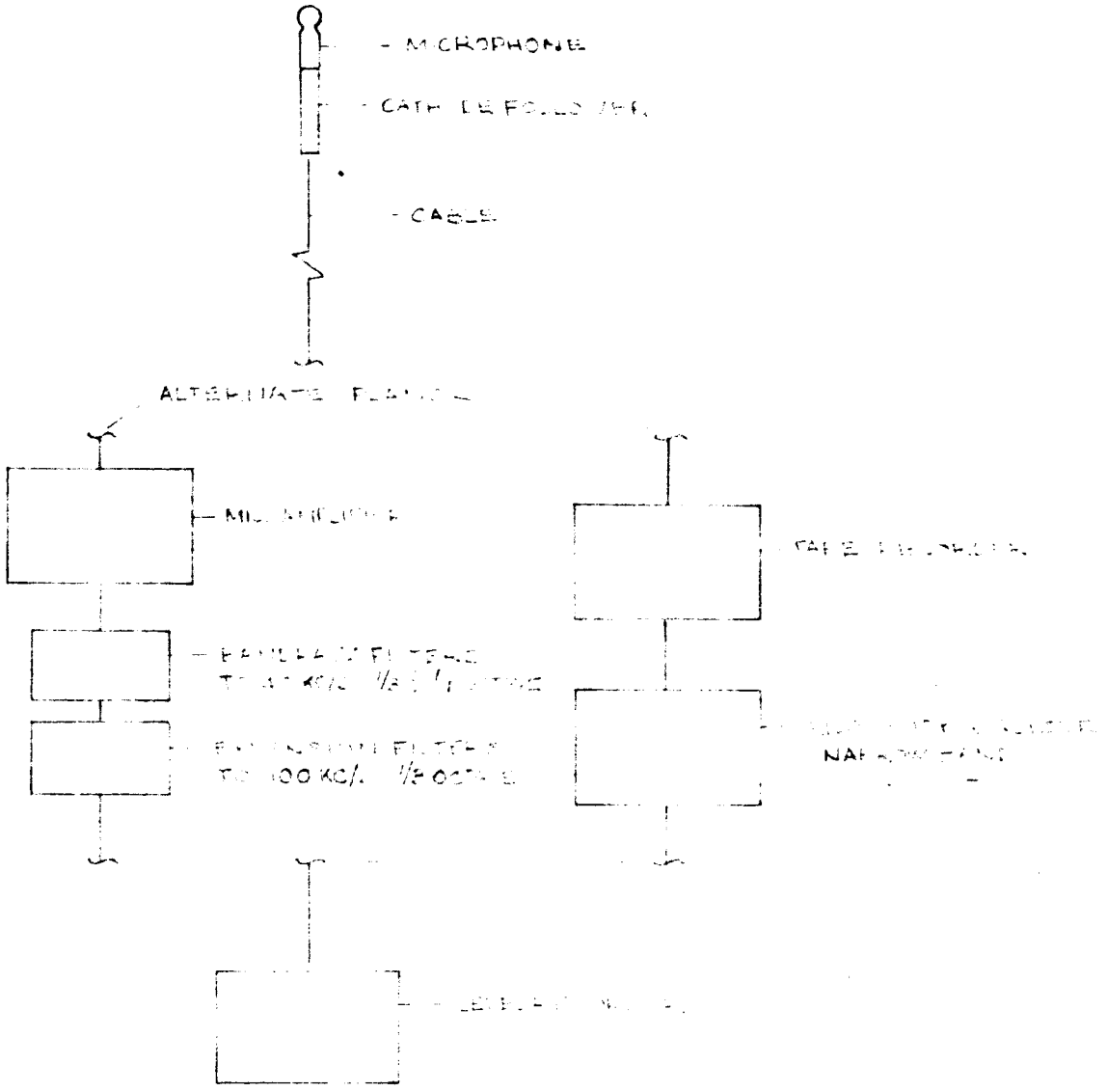
The initial facility requirements, as outlined in the original research proposal, were planned around experimental investigations to be conducted at an indoor as well as an outdoor site. The high frequency near field noise measurements (optically and otherwise) were to be conducted in a spacious but enclosed room. The far-field as well as the low frequency part of the near-field noise measurements were to be conducted in the open, away from any major reflecting surfaces. The intensity of the expected noise from highly underexpanded impinging jet flows was high (maximum for near-field noise up to 180 db). Due to the likely annoyance and discomfort of the noise source, the experimental noise observations in the open on campus were considered undesirable by the Syracuse University Administration. Since the compressed air facility is already located almost near the heart of the Syracuse University campus, and the noise facility cannot be located unreasonably away from the compressed air supply, it was decided to seek a single suitable indoor location. This shifted the essential environmental feature of no-reflection of the outdoor site to the indoor site in addition to the original required features of the indoor site (i.e. large room; no outside vibrations or disturbance; no disturbance due to jet noise to others working in the vicinity; etc.). Specifically this meant the attainment of free-field conditions indoors in an anechoic chamber. From a scientific point of view, the use of the anechoic chamber for the jet noise investigations is preferable to the originally proposed indoor-

outdoor measurements. Therefore this solution was proposed to the Syracuse University Administration. Various sites were explored. None of the existing and available rooms were suitable for easy conversion to an anechoic chamber. Cost estimates for building an isolated anechoic chamber were obtained by Syracuse University for each of the sites proposed. These estimates were much higher than anticipated and were judged beyond Syracuse University budget limitations for a single experimental facility. After extensive and time-consuming reviews of the situation, Syracuse University has been convinced that the anechoic chamber is a desirable useful and productive research facility. A compromise was reached to minimize costs, and Syracuse University now plans to build an anechoic chamber in a room of approximately 20' x 20' x 20' with a cutoff frequency of 300 cps (Fig. 2). [redacted] It is planned to integrate the construction of the anechoic chamber with the building of a second engineering building, construction of which is scheduled to start in 1964. The program to the university architect requests preparation of the anechoic chamber in the first stage of the new building construction. The University believes that the anechoic chamber can be constructed and be ready for operational use in the late summer 1964. Similar statements were made by Dr. Ralph A. Galbraith, Dean, College of Engineering, Syracuse University in a letter dated December 12, 1963 which he sent to Dr. T.L.K. Smull, Director, Office of Grants and Research Contracts, NASA.

Personnel and Expenditures

During the first three months (June to August 1963), Mr. Francis Montegani, Instructor and Ph.D. student in the Mechanical Engineering Department, Syracuse University worked full-time on the project. In the same period Dr. D. S. Dosanjh, project director, devoted 20 per cent of his time to the project work. The space allocation difficulties, as noted in the report, were not resolved by the end of the summer period, and the actual experimental research work had to be delayed. Since the spade work for the design specifications of the experimental facility was essentially finished during the summer months and since the cause of the delay in suitable space allocation and its solution lay outside the control and prerogatives of the project director and since no systematic jet noise investigations were possible until the anechoic chamber was ready, it was decided to freeze starting September 1, 1963 any major personnel salary expenses to be covered by the NASA grant. Since then, the project director has devoted, on his own without cost to the NASA grant, whatever time was necessary to promote the building of the anechoic chamber facility with funds to be appropriated by Syracuse University. It is expected that working without any major expenditure from NASA grant funds (except for the purchasing of experimental equipment now actively under consideration) may continue for a few more months - at least until the building of the experimental facility reaches a stage where concrete scientific progress is possible. [redacted]. Due to this initial delay in undertaking the actual experimental work and thus the reduced rate of expenditures, it may become necessary later to request for a

suitable no-cost extension in the present termination date of May 31, 1966. However, every effort will be made to expedite the experimental work as soon as the anechoic chamber is constructed. In the meantime literature study, careful design of the experimental facility and purchase of the equipment is continuing. Also some preliminary experimental interferometric data on the near field noise from impinging jets will be gathered (in a room which is not anechoic). From these interferometric observations the maximum intensity, frequency and directionality of the intense near field noise will be deduced.


- MICROPHONE
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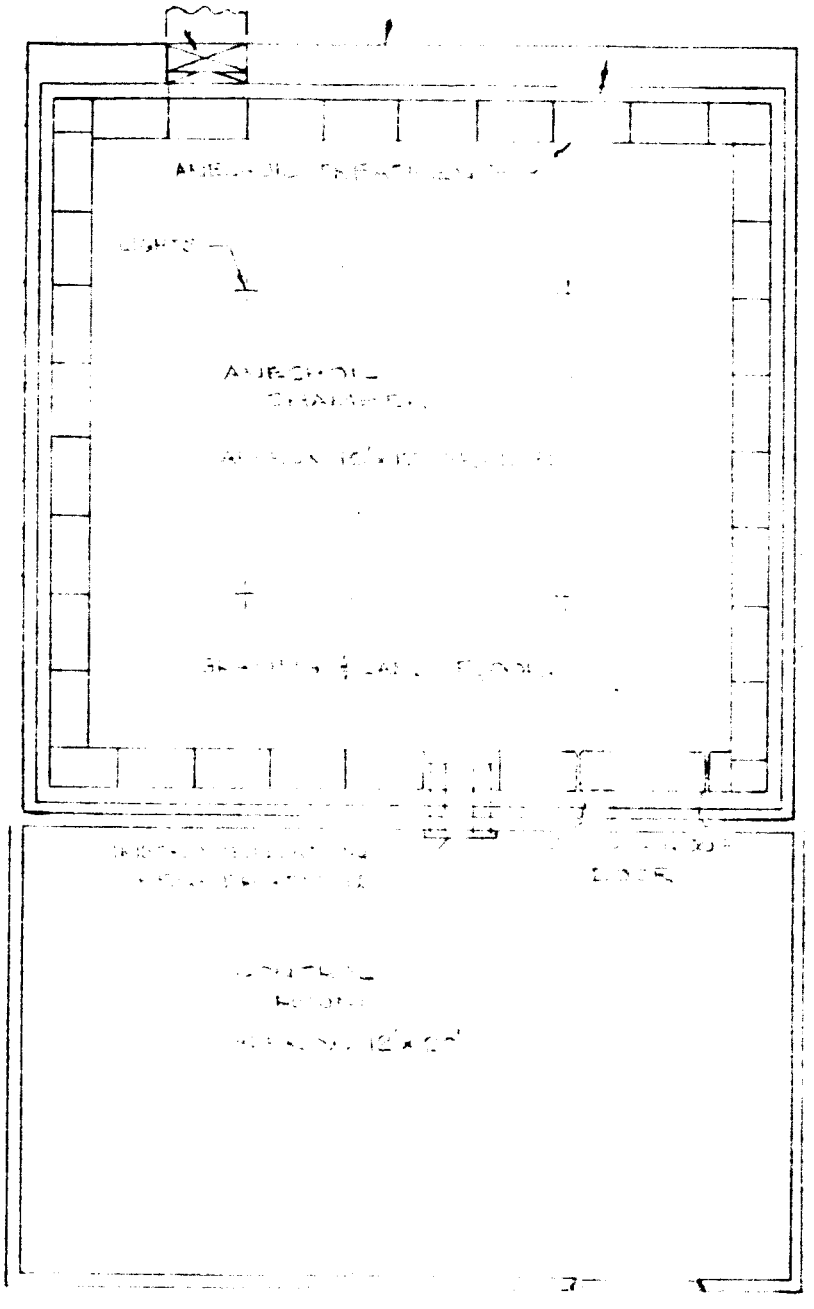
SPRING MOUNTED
ISOLATED INNER ROOM

20'x20'x20' MASONRY ROOM

EXHAUST SILENCER



ANECHOIC CHAMBER GENERAL PLAN

Fig. 2